AMERICAN SOCIETY OF HEATING, REFRIGERATING

AND AIR-CONDITIONING ENGINEERS, INC.

1791 Tullie Circle, NE Atlanta, GA 30329 404-636-8400

TC/TG/TRG MINUTES COVER SHEET

(Minutes of all meetings are to be distributed to all persons listed below

within 60 days following the meeting.)

TC/TG/TRG NO. TC4.11 DATE: February 7, 2001

TC/TG/TRG TITLE: Smart Building Systems

DATE OF MEETING: January 30, 2001 LOCATION: Atlanta

Membership status as of 1/23/01

Members Present	Appt	Members Absent	Appt	Ex-Officio Members and Additional Attendance
Jim Braun, Chair	99-01	Mark Breuker, Secretary	99-03	Osman Ahmed
Les Norford, Vice Chair	00-02	Steve Blanc, Member	99-03	J.R. Anderson

John House, Testing and Evaluation Subc	99-03	Mark Bailey, Handbook Subc/CM	98-	Mike Brambley
Todd Rossi, Technology Development Subc	99-03	Michael Brandemuehl, corresponding member	99-	David Branson
Rich Hackner, TC Webmaster	98-02	Thomas Engbring, corresponding member	99-	Marty Burns
Michael Kintner-Meyer, Communications and Integration Subc	99-03	Carlos Haiad, Member	00-04	Marwan Estiban
Barry Bridges, Member	98-02	Brian Kammers, corresponding member	96-	Ian Hensen
Natascha Castro, Member	00-04	Ron Nelson, corresponding member	98-	Srinivas Katipamula
James W. Gartner, Member	98-02	Barry Reardon, corresponding member	99-	Larry Luskay
Philip Haves, corresponding member	00-	Menelaos Sylianou, corresponding member	99-	Hung M. Pham
John Seem, Member	99-03			Andrew Price
George Kelly, Research Subc/CM	99-			Paul Riemer
Carol Lomonaco, Program Subc/CM	00-			Robert Sonderegger
Charles Culp, corresponding member	00-			Pornsok Songkakul
Arthur Dexter, corresponding member	00-			Max St-Denis
David Kahn, corresponding member	96-			Gene Strehlow
Curtis Klaassen, corresponding member	00-			Keith Temple
John Mitchell, corresponding member	00-			Jean-Christophe Visier

Robert Old, corresponding member	00-			Jonathan West
James Winston, corresponding member	96-			

DISTRIBUTION:

ALL MEMBERS OF TC/TG/TRG

TAC CHAIMAN: Edward Gut

TAC SECTION HEAD: Eckhard Groll

ALL COMMITTEE LIASONS AS SHOWN ON TC/TG/TRG ROSTERS:

Program: Emil E. Friberg Manager Of Technical Services: Martin J. Weiland

Research: Sheila Hayter Manager Of Research: William W. Seaton

Standards: David Knebel Manager Of Standards: Claire B. Ramspeck

Journal: Chad Dorgan

TEGA: William Knight

Special Publications: Joseph Driscoll

ADDITIONAL DISTRIBUTION: Visitors listed above

ASHRAE TC ACTIVITIES SHEET

DATE: 30 Jan 2001

TC NO. TC4.11 TC TITLE: Smart Building Systems

CHAIR: J. Braun VICE CHAIR: Les Norford

TC Meeting Schedule

Location, past 12 mo.	Date	Location, next 12 mo.	Date
Minneapolis	6/27/00	Cincinnati	6/26/01
Atlanta	1/30/01	Atlantic City	1/15/02

TC Subcommittees

Subcommittee	Chair
Technology Development	T. Rossi
Communications and Integration	M. Kintner-Meyer
Testing and Evaluation	J. House
Research	G. Kelly
Program	C. Lomonaco
Standards	R. Hackner
Handbook	M. Bailey

Research Projects

1043-RP Fault Detection and Diagnostic Requirements and Evaluation Tools for Chillers

1139-RP Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment

Long Range Research Plan (as approved by TC 4.11 at the Minneapolis Annual Meeting)

Rank	Title	W/S Written ?	TC Approved ?	To RAC ?
1	Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers – Phase II	Yes	Yes	No
2	Integrated Control for Building Services	Yes (3rd draft)	Yes	Yes, Rejected
3	Field Performance Assessment of Package Equipment to Quantify the Need for Monitoring, FDD, and Continuous Commissioning	Yes (1st draft)	No	No, RTAR rejected
4	Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic Systems	Yes (1st draft)	No	No
5	Prototyping and Field Testing of Utility – Consumer Information Services	Yes	No	No
6	Benchmarking of FDD Tools for AHU's	No[1]	No	No
7	Development of Fault Detection and Diagnostics for Sensor Failures	No[1]	No	No

1. One-page project descriptions have been written.

Handbook Responsibilities - none

Standards Activities - none

Technical Papers from Sponsored Research –

For 1011-RP:

PAPERS:

1. Kintner-Meyer, M., Burns, M. 2001. "Utility/Customer Information

Services

Part1: Descriptions of Services and Discussion on Interoperability for

Service

Implementation." ASHRAE Transactions 2001, Vol. 107, Part 1.

2. Burns, M., Kintner-Meyer, M. 2001. "Utility/Customer Information

Services

Part 2: Data Object Modeling and Mapping to BACnet." ASHRAE Transactions

2001.

Vol 1007, Part 1.

FINAL REPORT:

Kintner-Meyer, M., Burns, M. 1999. Utility/Energy Management and

Controls System

(EMCS) Communication Protocol Requirements. Final Report. ASHRAE

Research

Project 1011-RP.

For 1043-RP:

Comstock, M.C., Braun, J.E., and Groll, E.A., "The Sensitivity of Chiller Performance to Common Faults," Accepted for Publication in the International Journal of Heating, Ventilating, Air-Conditioning and Refrigerating Research, 2001.

Comstock, M.C., Braun, J.E., and Groll, E.A., "A Survey of Common Faults for Chillers," Submitted for Publication in the ASHRAE Transactions, 2001.

TC Sponsored Symposia (past 3 years, present, planned)

Title	**Date (Given or Planned)**
Controlling Outdoor Air Ventilation for 62-1989 (Atkinson; TC 1.4 lead with TC4.11 as co-sponsor)	Toronto, 6/98
Fault Detection and Diagnostics – Learning from Building Operations (Ahmed; TC4.6 lead with TC4.11 as co-sponsor)	Chicago, 1/99
FDD Methods and Evaluation Techniques (Castro)	Chicago, 1/99
Recent Results from Fault Detection and Diagnostic Research (Norford)	Atlanta, 1/01
Recent Results from Fault Detection and Diagnostic Research Part II (House)	Atlantic City, 1/02

TC Sponsored Seminars (past 3 years, present, planned)

Title	**Date** **(Given or Planned)**
Automated Response To Real Time Pricing (Kammerud)	San Francisco, 1/98
The Delivery of New Energy Services under Electric Industry Deregulation (Nordham; TC4.11 lead with TC 1.4 as co-sponsor)	San Francisco, 1/98
Benefits of Integrating HVAC with Non-HVAC Systems (Newman; TC 1.4 lead with SSPC 135 BACnet and TC4.11 as co-sponsors)	San Francisco, 1/98
Impact of Electromagnetic Interference on Control Systems and Global Standards (Coogan; TC 1.4 lead with TC4.11 and TC 1.9 as co-sponsors)	San Francisco, 1/98
New Platforms and Gateways for Connecting into Building Management Systems (Phelan)	Toronto, 6/98
The Latest Control Communications Technologies (Gartner; TC 1.4 lead with TC4.11 as co-sponsor)	Toronto, 6/98
Customer Experience with Real-Time Pricing Electric Rates (Kintner-Meyer)	Chicago, 1/99
A Peek at a Real BACnet Building… GSA 450 Golden Gate BACnet Pilot Project (Blanc; TC4.11 lead, with TC1.4 co-sponsor)	Seattle, 6/99
State-of-the-Art Control Devices, Sensors, Motors and Intelligent Actuators (Atkinson; TC1.4 lead with TC1.2, SSPC 135 BACnet, and TC4.11 as co-sponsors)	Seattle, 6/99
Practical Experience Using DDC Systems for HVAC Commissioning and Continuing Evaluation (Bridges; TC1.4 lead with TC1.7, TC4.11 and TC9.9 as co-sponsors	Dallas, 2/00
Deregulation for Dummies (Haiad)	Dallas, 2/00
Evaluating the Benefits of Fault Detection and Diagnostics	Dallas, 2/00
Providing for the Most Important Part of a Smart Building Control System: People (Bridges)	Minneapolis, 6/00
Control Systems Integration, What's Happening with Practical Open-Architecture Solutions (TC 4.11 co-sponsor)	Minneapolis, 6/00
Deregulation and Energy Efficiency in the State of California (Haiad)	Minneapolis, 6/00
Diagnostics from an Operations Perspective, Needs and Experiences (Rossi)	Atlanta, 1/01

Adding New Life to Old System-Control Retrofit Case Studies (TC 1.4 lead)	Atlanta, 1/01
BACnet Manufacturer's Association (BMA) New Role in Testing the Interoperability of BACnet Systems (Newman)	Cincinnati, 6/01
Data-Modeling for Buildings Operation" (Kintner-Meyer)	Cincinnati, 6/01
Wireless DDC Control: Working a Net Without a Wire (TC 1.4 lead with TC4.11 as co-sponsor, Bridges)	Cincinnati, 6/01
Maximizing Facilities Performance with Computerization (TC 1.7 lead with TC4.11 as co-sponsor, Gartner)	Cincinnati, 6/01
Pattern-Recognition-Based Fault Detection and Diagnostics for Building Operation (TC 1.5 lead with TC4.11 as co-sponsor, Brambley)	Cincinnati, 6/01
Experience with California's Price Responsiveness Program (Kintner-Meyer)	Atlantic City, 1/02
Intelligent Agents What They Can Do For Your Building (Ahmed)	Atlantic City, 1/02
IFC's for Building Operations (Kintner-Meyer)	Atlantic City, 1/02
FDD for Operations People, A Perspective on Using FDD Tools (Rossi)	Atlantic City, 1/02

TC Sponsored Forums (past 3 years, present, planned)

Title	**Date** **(Given or Planned)**
Occupant Driven Interactive Building Control (Bridges; TG4.SBS lead with TC 1.4 as co-sponsor)	San Francisco, 1/98
Now That We Have the BACnet Standard Protocol, are DDC Programming Language and Application Standards Next? (Nesler; TC 1.4 lead with SPC 135 BACnet and TG4.SBS as co-sponsors)	San Francisco, 1/98
CAB and BACnet Similarities and Dissimilarities (Newman; TC 1.4 lead with SPC 135 BACnet and TC4.11 as co-sponsors)	Toronto, 6/98
How Can We Accomplish Multi-Vendor Interoperability in Existing Facilities? (Coogan; TC1.4 lead with SPC 135 BACnet and TC4.11 as co-sponsors)	Chicago, 1/99
What's ASHRAE's Role in Deregulation? (Blanc)	Seattle, 6/99
Measuring the Benefit of Fault Detection and Diagnostics (Breuker; TC4.11 lead with TC1.4 as co-sponsor)	Seattle, 6/99

What is ASHRAE's Role in Designing and Operating Buildings for More Frequent Power Interruptions? (TC 1.9 lead with TC4.11 as co-sponsor, Kuk)	Cincinnati, 6/01
Addressing the Need for Data Modeling Beyond Building Design – What Role Should ASHRAE Play? (Augenbroe or Ahmed)	Atlantic City, 1/02
Specifying Open LonMark DDC Systems (TC 1.4 lead with TC4.11 as co-sponsor, Pittal or Pouchak)	
How Should the Handbook Cover Network Technology? (TC 1.4 lead with TC4.11 as co-sponsor, Malfitano or Pouchak)	Atlantic City, 1/02
Should ASHRAE be involved in IFC and XML (Brambley)	Atlantic City, 1/02
New Sensor Technology, Other New Technologies (Kintner-Meyer)	Atlantic City, 1/02

TC Sponsored Public Sessions (past 3 years, present, planned)

Title	**Date** **(Given or Planned)**
Designing, Installing or Operating Engineers - Who Will Most Impact New Millenium Facilities? (Gartner; TC1.4 lead, with TC9.9 and TC4.11 as co-sponsors)	Chicago, 1/99

Journal Publications (past 3 years, present, planned)

Title	**When published**
None	

Minutes summary and activities sheet submitted by: Natascha Castro, TC4.11 Acting Secretary

TC4.11 Minutes

Minneapolis: Tuesday, January 27, 2000

Roll Call, Introductions, Approval of Minutes, Announcements

Chairman Braun called the meeting to order at 3:30 p.m. A roll call showed that a quorum was present. In attendance at the meeting were Braun, Norford, House, Rossi, Hackner, Kitner-Meyer, Bridges, Castro, Gartner, Seem, for a total of 10 of 13 voting members. He asked for introductions. Braun distributed the minutes from the Minneapolis meeting, the agenda (the agenda is in Appendix A), and the handbook vision/ research roadmap of the committee (the handbook vision/ research roadmap is in Appendix C).

Braun requested comments for minutes submitted from Minneapolis meeting. It was noted that the minutes showed the record of the vote was missing for program on page 9. It was moved (Norford) and seconded (Hackner) to accept the minutes from the January 2000 meeting. The motion was approved unanimously by voice vote.

Braun mentioned:

- There is an update to the roster. John house changed jobs and became the second member from the Iowa energy Center, therefore Natascha Castro rolled on to replace John as the representative from NIST and Kurt Klaassen rolled off. Natascha is now acting Secretary and Webmaster.
- ASHRAE wants to begin technical bulletins of results coming out of projects and we may have results from FDD that we want to present to membership.
- ASHRAE is also encouraging TC's to put seminar materials available on the web site. House inquired about posting symposium overheads.

Braun will look into whether ASHRAE approves of this.

Research Issues

Braun stated that there is a research slowdown. The total budget decreased from $3.2 million to $2.9 million, creating a research bottleneck. The number of outstanding projects is to be reduced from 132 to 100. Braun stated that with RTAR's approved only once a year, we need to be careful how we prioritize research. An idea is to develop a research roadmap. The committee will decide in Cincinnati what to propose for future RTARs.

Braun stated that draft research roadmap that he developed with help from House/Kelly was sent out to members and distributed with the agenda. It covers:

I Elements of a Smart Building (Basic sections of the handbook)

II Interconnectivity / Interoperability

III Integrated Controls, Services and Facilities Management

IV Self-Configuring Systems

V Automated Commissioning Systems

VI Automated Fault Detection and Diagnostics

Discussion followed:

Kelly added the II should cover interfacing to other outside building services.

Burns, asked where predictive building controls fall under the scope? Braun stated it was in section III. Haves wondered whether this is the scope of

4.6. Braun replied that there is overlap with some of the scope of TC 4.6, but that at this point we should outline all of the elements of a smart building system and later decide what contributions TC 4.11 can make. It was also stated that one element missing from the outline was documentation of the benefits of smart building system components. This will be added.

Kintner-Meyer commented that DOE started a research roadmap with a vision of what a building of the future would look like and then looked at technical gaps and from there came to projects with long-term benefit. This was a top down, rather than this bottom up approach. What these elements do and how they interact may not be so clear. Should we start with vision?

Brambley suggested that for, smart building systems it may not be possible for us to to establish needs and therefore showing what we can provide may be a better approach. Kelly agreed, membership may not be able to identify needs. The role of the TC may be to identify what is beneficial in the future. Brambly proposed to use slides to present SBS to local chapters and get member attitudes about proposals. Braun suggested that developing a seminar to discuss this is a good way to get the materials pulled together. It was also suggested that chapter presidents are always looking for material to include in their newsletters.

Haves suggested a conference call for 5 the TC subcommittee and committee chairs to make road mapping plan to coordinate research. Seem said that the idea of going to short-term research is wrong. We need to better market what we are currently doing. Braun suggested that the most of the work is done at meetings, therefore for short-term, a bottom up approach may be the most effective.

Braun asked subcommittee chairs to build their own roadmaps, it was agreed for next meeting.

Braun then asked for updates from the subcommittee chairs.

Technical Development Subcommittee (Rossi)

Rossi reported that there are two projects under way.

Fault Detection and Diagnostic Requirements and Evaluation Tools for Chillers (1043-RP).

Seem reported that the PMS met Monday, that good progress was made, completing the literature search and sensitivity analysis. The project is scheduled to end in March and needs a no-cost extension until July. It was moved (Seem) and seconded (House) to grant a no-cost extension to Purdue University as follows: "TC 4.11 recommends that ASHRAE extend a no-cost extension to Purdue University for completion of 1043-RP until 6/31/2001". The motion was passed with 9 in favor, none opposed, and 1 abstention.

Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment (1139-RP).

Katipamula reported that significant progress was made including modelling with good results. The plan is to have a draft report for next meeting., but the project is six months behind due to problems with some resources. It was moved (Seem) and seconded (Rossi) to grant a no-cost extension to Drexel University as follows: "TC 4.11 recommends that ASHRAE extend a no-cost extension to Drexel University for completion of 1139-RP until 8/31/2001.

Discussion followed, a clarification of what is left to do was requested. Reddy reported that four models were examined, as well as 2 estimation techniques. This broadened the original scope, but evaluation was to include their own data, adding to Purdue data".

The motion was passed with 9 in favor, none opposed, and 1 abstention.

There are currently three RTARs. Rossi reported that the subcommittee discussed a new project on sensor fault detection, **Development of FDD for Sensor Failures**. Dexter revised the workstatement developed by Haves.

A new idea was presented for plug and play control systems. Michael Kintner-Meyer agree to take the lead on developing this RTAR. Jim Braun agreed to help.

Rossi announced that TC 4.11 has program forWednesday 10:15, giving a seminar titled “Diagnostics from an Operations Perspective, Needs and Experiences (Rossi).

The minutes of the subcommittee meeting are in Appendix D.

Communications and Integration Subcommittee (Kintner-Meyer)

There is one current work statement being developed by this committee. It was developed two years ago and addresses the problem of prototyping and testing of utility/customer communication services. A data model which described load monitoring, RTP, weather, energy efficiency, demand bidding was developed under previous work (RP-1011). The current work statement proposes to extend the work

- Phase 1: Simulation of the communication
- Phase 2: Field trial

The committee believed that this would be an extension of the BACnet standard. To gain support Kintner-Meyer gave a presentation to the BACnet committee last meeting and follow up presentation was given by Burns to the BACnet committee on Sunday. Kintner-Meyer reported that Bushby suggested testing mapping mechanism using ASHRAE research. Kintner-Meyer will work with BACnet committee to get endorsement of committee.

Need for self-configuration schemes, plug and play schemes, to be evaluated. Statement to review what currently exists. Braun and Kintner-Meyer will work on an RTAR for the next meeting.

Other activities:

Duane Barrett was leading the first GPC meeting in Atlanta. The goal of this GPC is to be ASHRAE's focal group for XML definitions for HVAC & R applications. This group will develop a website for an online XML data dictionary. It was agreed that it is high priority to get this website up and operational by the next Meeting in Cinncinati.

Duane Barrett was nominated to be the chairperson for the GPC. Furthermore, a list of voting members was developed. The title of the GPC and objectives were formulated. Duane went to ASHRAE on Tuesday 1/30/2001 to receive approval for founding this new GPC. In preparation for the next ASHRAE meeting, it was agreed to hold a teleconference call among the voting members to coordinate further activities at the Meeting.

The minutes of the subcommittee meeting are in Appendix E.

Testing and Evaluation Subcommittee (House)

Integrated Control for Building Services

House reported that RAC rejected the RTAR for Integrated control of building services. The subcommittee decided to kill that RTAR.

Field Performance Assessment of Package Equipment to Quantify the Need for Monitoring, FDD, and Continuous Commissioning.

This is a new work statement developed by Rossi to look at performance of a large number of units, then take a subset and fix them to determine how much improvement could be made. This RTAR was rejected for various reasons, including how to keep manufacturers names out of study. The subcommittee feels that this can be accomplished by reworking and clarifying this. Braun and Rossi will work on this rewrite. Rossi is exploring cost-sharing opportunities and is following up with discussions with DOE. Watson suggested contacting Elizabeth Jones at ARTI (CR-21) for possible cost sharing. Katipamula is involved. Bridges suggested BOMA, but House stated that they were not likely to provide $.

Resolving Discrepancies between Multiple, Hierarchically Related, FDD Systems.

Brambley has been reworking the workstatement. He suggests a literature review to look at other areas for conflict resolution, identifying potential and where existing methods could be applied. The workstatement is well defined. Next summer we will decide its priority.

Benchmarking Of FDD Tools For Air Handling Units

The workstatement is a follow-on to 1020RP, comparing 2 FDD methods. Want independent contractor to get tools and make an evaluation. There is concern that ASHRAE may reject as a product comparison but the subcommittee felt that developing the tools to evaluate would be valuable.

The minutes of the subcommittee meeting are in Appendix F.

Research Subcommittee (Kelly)

Kelly distributed the research plan for the coming year, included in Appendix G and summarized as follows:

Priority	Project	Contributors	Status
1.	Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers – Phase II	John House Srinivas Katipamula	Approved in Minneapolis 10-0-0 (CNV). Submit to RAC AFTER Phase I is completed.
2.	Integrated Control for Building Services	Mike Brambley John House Ron Kammerud John Mitchell	Original TRP Rejected by Tech. Council. Decided in Minneapolis to rework and reconsider in Atlanta. Explore possible ARTI funding. (Needs cover letter to RAC saying this is

			"second attempt".)
3.	Field Performance Assessment of Package Equipment to Quantify the Need for Monitoring, FDD, and Continuous Commissioning	Todd Rossi Mark Breuker Jim Braun	Draft WS exists. Todd Rossi will revise and complete BEFORE Atlanta meeting. Possible TC vote in Atlanta.
4.	Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic Systems	Mike Brambley Todd Rossi	Mike Brambley will scale back scope and have revised WS by Atlanta.
5.	Prototyping and Field Testing of Utility – Consumer Information Services	Michael Kintner-Meyer Marty Burns Chuck McParland	In the hands of an "Action Committee" set up by SSPC 135. Reconsider in Atlanta.
6.	Benchmarking of FDD Tools for AHU's	John House Les Norford	An RTAR exists.
7.	Development of Fault Detection and Diagnostics for Sensor Failures	Phil Haves Arthur Dexter	One page description exists. Two page Issues Paper handed out by Phil Haves in Minneapolis.

Kelly reported that if Item 1 (1043-RP) is completed by the annual meeting, we will not have to submit as an RTAR, otherwise must be priority 1. Item 2 has been dropped. Item 3, submitted last fall, was rejected. Item 4 was rewritten (Brambley). Item 5 waiting on feedback from 135, but can go ahead without endorsement. Item 6 was renamed as "Method of". Item 7 "Smart sensor systems for…" New item concepts for "Self configuring systems"

Kelly suggested that instead of three, one-hour, subcommittee meetings to discuss roadmapping, it might be more effective if committees discuss for 45 minutes a bottom up approach and then use the last 45 minutes of the research subcommittee meeting to discuss top-down. Program would be

discussed for 5 minutes within 45 minutes.

Work needs to be done up front to prepare items for discussion. Subcommittee chair must lead their roadmapping sessions. Research chair would lead integration discussion.

Program Subcommittee (Lomonaco)

Lomonaco summarized the program for the Atlanta meeting. In Atlanta, we had a Symposium. Seminar on Deregulation that was well attended and we were co-sponsors for seminars 29 and 46.

Carol reported that from here on the program is to be entered on-line. If there are any problems, the deadlines still apply. Electronic signatures are not allowed, therefore, these must still be submitted with paper copies. Program chairs are to try on-line submissions and report their experiences at Cincinnati.

Carol presented the program for Cincinnati. The TC is sponsoring two seminars, “BACnet Manufacturer’s Association (BMA) New Role in Testing the Interoperability of BACnet Systems” chaired by Newman, and “Data-Modeling for Buildings Operation” chaired by Kintner-Meyer.

Osman Ahmed’s program,” Addressing the Need for Data Modeling Beyond Building Design – What Role Should ASHRAE Play?”, was delayed to Atlantic City.

Carol reported that we were asked to co-sponsor two seminars “Wireless DDC Control: Working a Net Without a Wire” (TC 1.4 lead, Bridges), ”Maximizing Facilities Performance with Computerization” (TC 1.7 lead, Gartner), and “Pattern-Recognition-Based Fault Detection and Diagnostics for Building Operation” (TC 1.5 lead, Brambley). The committee was also asked to co-sponsor a forum “What is ASHRAE’s Role in Designing and Operating Buildings for More Frequent Power Interruptions? (TC 1.9 lead, Kuk)

There was discussion whether “Experience with California’s Price Responsiveness Program“ should specify California, and whether it may not be

timely. The committee decided to keep it in the program.

It was moved (Gartner) and seconded (Bridges) to approve the program for Atlanta as presented by Lomonaco, with the BMA seminar as priority 1, the Data modeling seminar as priority 2, and co-sponsorship. The motion passed by unanimous vote, 9,0,0. Programs as subsequently approved by ASHRAE are tabulated at the beginning of these minutes.

Old Business

The only old business was the research roadmap and a plan has been established.

New business

Gartner reported that one of the tours for Cincinnati is tailored for TC 4.11. It is a tour of the Univ. Cincinnati, looking at studies on indoor environments, the design of the architecture of the campus, and facilities automation. The tour will be Monday June 25, 2001 from 2:30-5:30 p.m.

There was a suggestion from TAC that a new technical research group be created to produce a guide on building maintenance, total building control and total building commissioning. One of the elements was diagnostics. TC 1.4, 1.7, and 9.9 have already responded, stating that they have already covered this material and if the group is formed, they want to be a part of it. TC 4.11 and 4.6 did not receive the notice.

It was moved (Gartner, Bridges 2nd) that TC 4.11 support Jim Braun's response to the letter sent out by TAC indicating our concern. The motion

was approved unanimously.

Website

Natascha updated the website to follow the new TC structure.

Chairs of 4.11 seminars are asked to request their speakers whether they would like to have their slides posted on the website. Seminar overheads are to be submitted to the webmaster.

Adjournment

It was moved (House), seconded (Gartner), and unanimously voted to adjourn at 6 p.m.

Appendices

1. Call to Meeting and Agenda
2. Scope and Organization
3. Handbook Vision/ Research Roadmap
4. Technology Development Subcommittee Report
5. Communications and Integration Subcommittee Report
6. Testing and Evaluation Subcommittee Report

7. Research Plan and Activities

8. Program Subcommittee Report

9. List of Subcommittee Attendees

Appendix A.

Call to Meeting and Agenda

ASHRAE American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

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1791 Tullie Circle, NE, Atlanta, Georgia 30329-2305 404-636-8400 | Fax 404-321-5478

Reply to: Jim Braun

Ray W. Herrick Labs

Purdue University

W. Lafayette, IN 47907

(jbraun@ecn.purdue.edu)

January 4, 2001

Dear TC 4.11 Member, International Member, or Corresponding Member,

The **TC** on Smart Building Systems and its subcommittees will meet in Atlanta (Georgia World Congress Center, GWCC) according to the following schedule:

TC 4.11 Tech. Development Sunday (1/28) 3:00-4:00p 363W

TC 4.11 Comm. & Integration Sunday (1/28) 4:00-5:00p 363W

TC 4.11 Testing & Evaluation Sunday (1/28) 5:00-6:00p 363W

TC 4.11 Smart Building Systems Tuesday (1/30**) 3:30-6:00p 369W**

TC 4.11 PMS 1139-RP Sunday (1/28) 6:00-8:00p 363W

TC 4.11 PMS 1043 RP Monday (1/29) 3:15-4:15p 172W

The TC is the sponsor or co-sponsor for the following sessions in Atlanta:

Symposium AT-01-14: Recent Results from Fault Detection and Diagnostic Research, Tuesday, 1/30/2001 - 10:15 AM - 12:15 PM, Room: 365/366W, Chair: Les Norford

Seminar 29: **Adding New Life to Old Systems: Control Retrofit Case Studies**, Tuesday, 1/30/2001**,** 10:15 AM - 12:15 PM, Room: 364W, Chair: Gaylen V. Atkinson

Seminar 46: **Diagnostics from an Operations Perspective: Needs and Experiences**, Wednesday, 1/31/2001, 10:15 AM - 12:15 PM, Room: 363W, Chair: Todd M. Rossi

(See the ASHRAE Program Booklet to confirm session locations and times.)

Attached is a draft agenda for the full TC 4.11 committee meeting in Atlanta. I hope to see you all there.

Jim Braun

Chairman, TC 4.11

ASHRAE TC 4.11, Smart Building Systems

2001 Winter Meeting, Atlanta

AGENDA

Location: Room 369W, Georgia World Congress Center (GWCC)

Date: Tuesday, January 30, 2001

Time: 3:30 - 6:00 p.m.

1. Roll call and introductions

2. Approval of Minutes from Minneapolis

3. Announcements

3. Research Issues

- research bottleneck (RTAR process, ASHRAE $)
- handbook vision / research roadmap

5. Technology Development Subcommittee Report (Todd Rossi)

1043-RP, Fault Detection and Diagnostic (FDD) Requirements and Evaluation Tools

for Chillers (John Seem)

1139-RP, Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment (Mark Breuker)

Draft Work Statements

Other activities

6. Communications and Integration Subcommittee Report (Michael Kintner-Meyer)

Draft Work Statements

Other activities

7. Testing and Evaluation Subcommittee Report (John House)

Draft Work Statements

Other activities

8. Research Subcommittee Report (George Kelly)

New Work Statements

Research Plan

9. Program Subcommittee Report (Carol Lomonaco)

Feedback from seminars and forums for Minneapolis & Atlanta

Plans for Cincinnati (6/2001). Atlantic City (1/2002), & Honolulu (6/2002)

10. TC 4.11 Website (Natascha Castro)

11. Old business

12. New business

13. Adjournment

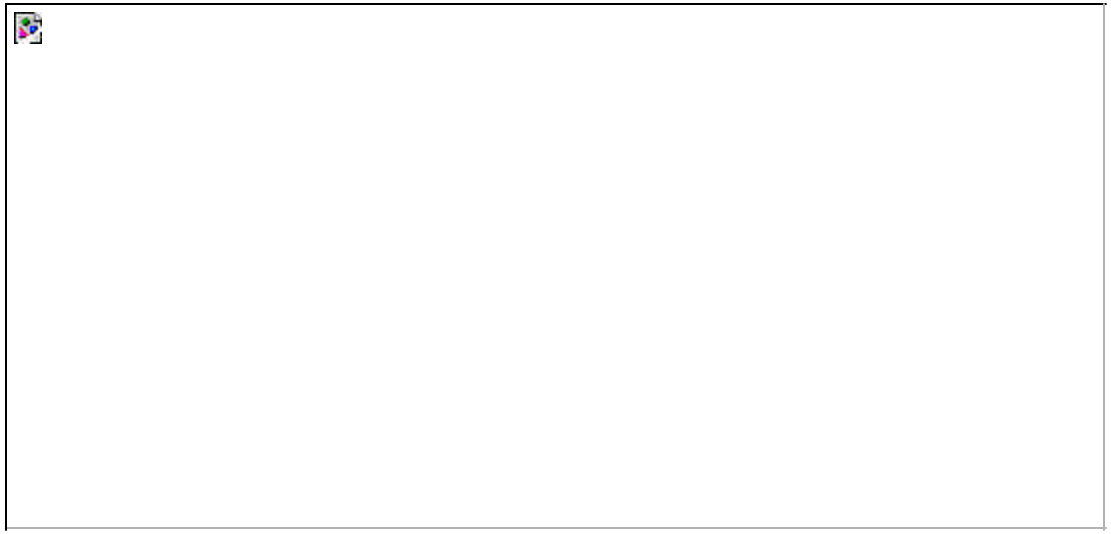
Appendix B.

TC 4.11, Smart Building Systems Scope and Organization

July 1, 1999

Overall Committee Scope

The Technical Committee on Smart Building Systems (SBS), TC 4.11, is concerned with the development and evaluation of technologies that could enable the widespread application of smart building systems. “Smart” buildings should take advantage of automation, communications, and data analysis technologies in order to operate in the most cost-effective manner. This implies integration of building services such as HVAC, fire, security, and transportation; the automation of many of the operation and maintenance functions traditionally performed by humans; and the interaction with outside service providers such as utilities, energy providers, and aggregators. Currently, three subcommittees form the backbone of the TC’s activities: technology development, communications and integration, and testing and evaluation. The scope and activities of these subcommittees loosely follow the product development process as depicted in following flow chart and as defined in the following sections.



Technology Development Subcommittee

The Technology Development Subcommittee is concerned with research issues associated with the development of emerging smart building technologies such as (but not restricted to) automated commissioning, performance monitoring, fault detection and diagnosis, optimal maintenance scheduling, and optimal control. The primary outcome of research endorsed by this subcommittee is expected to data and models that enable development of the technologies and comprehensive methods that are the basis of the technologies. An integral part of the development process is simulation and laboratory testing. Proposed designs must be tested and modified prior to field evaluation. Specific research topics that are ongoing or planned under this subcommittee are:

- 1043-RP Fault Detection and Diagnostic (FDD) Requirements and Evaluation Tools for Chillers
- 1139-RP Development and Comparison of On-Line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment
- Fault Detection and Diagnostic Methods for Chillers
- Development of Fault Detection and Diagnostics for Sensor Failures

Communications and Integration Subcommittee

The Communications and Integration Subcommittee is concerned with research issues associated with enabling the seamless interaction of smart building components and services. An important aspect of this work is to identify the information that is necessary to support smart building technologies, and to identify the requirements of communication protocols to support the exchange of this information between different building services, between buildings and utilities, between multiple buildings, with outside service providers, etc. Specific research topics that are ongoing or planned under this subcommittee are:

- 1011-RP Utility/EMCS Communication Protocol Requirements (Completed: 6/99)
- Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic (FDD) Systems
- Prototyping and Field Testing of ASHRAE's Utility Consumer Interface Models (UCIM)

Testing and Evaluation Subcommittee

The Testing and Evaluation Subcommittee is concerned with research issues associated with assessing the benefits (market potential) and performance of smart building technologies. Research endorsed by this subcommittee is expected to result in data, metrics, methods, and tools/standards/guidelines for quantifying smart building system benefits and performance in a standardized manner, as well as findings from the actual application of these metrics, methods and tools. Specific research topics that are ongoing or planned under this subcommittee are:

- 1020-RP Demonstration of Fault Detection and Diagnostic Methods in a Real Building
- Integrated Control for Building Services
- Quantifying the Benefits of HVAC Equipment Monitoring and Fault Detection
- Multi-Application Comparison of Fault Detection and Diagnostic Methods

Appendix C.

TC 4.11 Smart Building Systems

Handbook Vision / Research Roadmap – January, 2001

I. **Elements of a Smart Building**

- interconnectivity / interoperability
- integrated controls, services, & facilities management
- self-configuring systems – "plug and play"
- automated commissioning systems
- automated fault detection and diagnostics – continuous commissioning

I. **Interconnectivity / Interoperability**

- alternative architectures – advantages and disadvantages
- communication protocols[1]
- product data models[1]
- system reliability & security
- utility building interfaces

- user interfaces

I. **Integrated Controls, Services, and Facilities Management**

- benefits of integration[2]
- supervisory level control in a distributed and fully integrated environment
- safety, reliability, security services – hardware and software requirements
- facilities management – information requirements & management
- conflict resolution between subsystems

I. **Self-Configuring Systems**

- hardware requirements
- information requirements
- algorithms

I. **Automated Commissioning Systems**

- hardware requirements
- information requirements
- test sequences and algorithms

I. **Automated Fault Detection and Diagnostics**

- benefits of FDD[2]
- hardware requirements[1]
- information requirements[1]
- algorithms[1]
- conflict resolution between FDD subsystems[2]

I. **Self-Configuring Systems**

II.
- hardware requirements
- information requirements
- algorithms
- performance evaluation

I. **Automated Commissioning Systems**
- hardware requirements
- information requirements
- test sequences and algorithms
- performance testing

I. **Automated Fault Detection and Diagnostics**
- hardware requirements
- information requirements
- algorithms
- conflict resolution between FDD subsystem
- evaluating the performance of FDD systems

Appendix D.

TC4.11 Technology Development Subcommittee Meeting

. Chair: Todd Rossi

Atlanta, Winter Meeting 1/28/01

- Todd Rossi welcomed the attendants of the subcommittee meeting and asked Jim Braun to explain the new research funding situation.
- Jim Braun explained that ASHRAE's research budget has been significantly reduced this year. ASHRAE even withdrew RFP published on the Web to delay the initiation of new projects. No new workstatements will be approved until the already approved workstatements are published for bids. Jim Braun further mentioned that RTAR will be evaluated only once a year. To increase the chances of approving workstatements we need to focus on solid research-based projects. In the past, we had some FDD promotional type workstatement, which are not favored by ASHRAE at the current time.
- Rich Hackner mentioned that there is a backlog of 14 workstatement according to Bill Seaton.
- Mark Breuker asked whether the cap on research necessitates TC4.11 focus to be more handbook and program-oriented.
- John Mitchell indicated that there is a notion in ASHRAE that not enough of the research benefits reach the ASHRAE community. So some educational aspects are desirable and may need to be emphasized.
- There is a disconnect between Jim Braun's concept of focusing more on basic research and John Mitchell's notion to do more for the practicing ASHRAE member.
- George Kelly reported that ASHRAE has recently approved research along the traditional lines of basic research and that TC4.11, therefore, should consider this trend.
- Jim reported on the progress of the ASHRAE research project 1043. The transient model still needs some work. The Phase II project

requires that 1043 be completed. The TC already approves this workstatement. There doesn't need to be any further discussion on this workstatement. Jim Braun mentioned that he will ask for a no-cost extension on 1043-RP until the summer meeting

- Arthur Dexter presented a new workstatement titled: "Smart sensor systems for reducing measurements errors in air—conditioning systems". A workstatement draft has been developed. The objectives are: (1) determine the common problems of sensors, (2) identify problems, and (3) compensate for any problems. Use data fusion techniques (statistical) for the compensation strategies. (See workstatement draft). Develop smart sensor systems. Sensor problems could include inadequate location of flow sensors or simply bad or inadequate measurement methods for airflow in ducts. Cost for the project is to be determined. George asked as to whether or not particular applications have been identified. Arthur suggested air-handling applications would be prime candidates. George was concerned about the breadth. He would like to narrow it down for the first draft. John Michell suggested that the first objective could be one project by itself. Jeff Haberl made some comments related to be more precise by narrowing the scope down to air-side application to make the workstatement biddable. Agami Redy added to the discussion by suggesting to distinguish between bias and accuracy. Arthur summarized the comments made during the discussion
  - narrow it down by application.
  - break it to pieces.
    - FDD
    - compensation
  - narrow to flow and temperature, humidity sensors.

Jim Braun suggested to produce an RTAR for the workstatement presented by Arthur Dexter.

- Mark Breuker reported that the contractor (Drexel University) of research project 1139 made good progress. The PMS will meet after the subcommittee meetings.

- Jim Braun suggested Plug and Play concept for BAS. Michael Kintner-Meyer offered to discuss this topic in the Integration and Communication Subcommittee. Agami Redy suggested that our focus in TC4.11 may be too narrowly defined on equipment only and ought to be broadened to include other buildings as well.

Carol: Program

2 seminars and 1 forum were not approved for the Atlanta Meeting. Carol suggested to re-submit the seminars and one forum for the Cincinnati meeting in the summer. John House may get 3 papers for a symposium on FDD, which was dropped for the Atlanta meeting. Title: Part 2: FDD. John House suggested to delay the symposium to Atlantic City for the Winter Meeting to get an additional paper.

Submitted by

Michael Kintner-Meyer

Appendix E.

TC4.11 Communications and Integration Subcommittee Meeting

Chairman: Michael Kintner-Meyer

Atlanta,January 28, 2001

1. Michael Kintner-Meyer reported on provided an update on work statement involving an extension to BACnet to communicate utility information (Title???). Discussions with the BACnet committee during this meeting provided encouragement to move forward.

- George Kelly suggests flushing out the work statement and then condensing it into an RTAR to vote on at the summer meeting.
- If it is approved in the fall, then the work statement can be submitted next winter.

1. Michael KM discusses a new conceptual WS – self configuration. It addresses a need in control systems to improve reliability, reduce time needed to configure, etc. Base this technology on plug-and-play technology in the PC industry.

- Tasks:

1. Literature review on plug and play. What have other domains done?
2. Are these schemes applicable to HVAC apps?
3. What are the requirements for providing a self-configuring environment?

- Katipamula suggests there is a need for a standard. Maybe the Microsoft model would be helpful. Sun's Genie standard?
- There is a comment that if insufficient attention is given to establishing the requirements, the resulting standard can be lacking.
- George Kelly: Is this an application for the XML effort?

- Jim Braun and Michael KM will work on a work statement so it can be reduced to an RTAR to vote in the summer. George K. thinks it is important to have an RTAR+ by the summer that flushes out more details.

3. Michael KM discusses communication technology for demand control. Examples include shedding loads, resetting thermostats. There are examples of this happening in CA this summer. How does this translate into a work statement? Certainly there is content for seminars.

- Agami suggested that the communication must extend beyond the scope of a single building.
- Les Norfold responding to a question providing a list of information beyond electricity demand that can be communicated including data needed for aggregating loads. There may be more information coming out of 1146 in June that may be helpful. Les will email a list of 2-3 suggestions to Michael.
- Srinivas suggested that this time next year there will be more information about load curtailment. ENRON is investing in this technology. There are many hidden transaction costs that are making $500/MWh unattractive.
- Agami: Why not focus on a single building? How to build intelligent buildings to know how to shed loads in an acceptable manner to the occupants?
- J. Habrel: Need to look closer and using better weather forecasts, more specifically looking at moving weather fronts. Cross over to TC4.2.
- George commented on Cliff's forum on dynamic building control. The owners showed little interest in it. The owners would rather turn down lights then compromise in temperature.

3. Program (Carol L.):

- Data modeling seminar to create an overview of how to model building data so it can be shared between different aspects of designing and running a building. (Seminar: Michael Kintner-Meyer, 1.5 & 4.6)
- Phil H. suggests new program for computer applications continuing on senimar 27 in Atlanta… "Interoperable computer applications for the HVAC industry". GPC XML Definitions for HVAC&R
- Other programming items carried over from last meeting: "Intelligent Agents" (Seminar: Osman Ahmed) and "Addressing the Need for Data

Modelling Beyond Building Design – What Role Should ASHRAE Play" (Forum: Osman Ahmed and Godfried Augenbroe, 1.4 & 1.5)

- "Experience with California Price Responsiveness Program" seminar planned for Atlantic City (Mark Brueker and Michael Kintner-Meyer)

Submitted by

Todd Rossi

Appendix F.

TC4.11 Testing and Evaluation Subcommittee Meeting

Chairman: John House

Atlanta, January 28, 2001

1. RAC rejected completely the work statement on "Integrated Control and Building Services". To survey oriented not enough research substance. There is consensus by Jim Braun, George K., John House to drop this effort.

2. RTAR on Todd Rossi's WS on "Field Performance Assessment…"

- Todd Rossi distributed RAC comments on rejected RTAR., draft WS, and sample results from field work conducted by Field Diagnostics.
- RAC main comments: scope too broad (too large a sampling) and concern about keeping manufacturer's names out of the study.
- Phil H: Change background to describe benefits of FDD instead of starting with a statement about barriers to FDD. Commissioning people have also had trouble getting people to buy into cx and they think if you could demonstrate its benefits, people would practice it.
- Jim B: Important to out committee
- George K: May run into problems if this is perceived as market research, even if we address the other comments
- Dick Kelso: Address comments 1-by-1 (include cost estimates, FDSI data). Show how it fits in with the broader goals of the committee, ASHRAE and its members.
- John Mitchell: can we target the justification more… who will this impact and why
- Phil H: Make it sound more like the results of the survey will help quantify the need for FDD tools instead of having it sound like were

searching for research by do field survey.

1. Work statement: “Multi-hierarchical diagnostics for HVAC systems”

- Michael Brambley
- Reduce scope, literature search, how to apply to different industries
- Revised WS is available
- Literature survey, identify FDD conflicts, evaluate resolution methods, final report.
- Phil H. suggests that this only becomes an issue when there are multiple overlapping FDD methods.
- Jim B. thinks the WS has improved and it is clear.
- Les, George K: This is a good WS. It can be easily reduced to an RTAR and put to a vote next summer.

1. John House: WS on “Benchmarking of FDD tools for AHUs”

- Follow on to 1020
- Have a contractor independently test different FDD methods for AHUs.
- Michael B: ASHRAE wants to stay away from product comparisons. John H. agrees.
- Phil H: Need a method for testing FDD methods. Data and criteria. Emphasize procedure instead of results. Agreement with Jim B., Arthur D., Mark Breuker.
- Mike Brambley: Concerned about comparing different methods in different stages of development with different intended users. Wayne ??? agrees that this a quagmire.
- John Mitchell: How about a competition like the energy shootout? John H. is concerned that this also tests the user’s ability to extend the capabilities of the tool.
- Arthur D: Not wanting to get into the business of comparing commercial products is not a good reason not to do it. It is important. If not

ASHRAE, then who?

- John House: Avoid comparing methods. Develop data and methods that others can use.
- Wayne: Set standards for FDD methods.
- Jean-Christophe: There are standards in Europe for testing BEMS systems. This can be extended to FDD. We need a standard… a checklist
- Mike B: Develop performance indices that can be of value in the beginning.

Program:

- Mike Brambley: “Pattern recognition based FDD for building operations” seminar.

Submitted by

Todd Rossi

Appendix G.

TC 4.11 Smart Building Systems

Research Plan and Activities

July 2000

Research Objectives: The long-term goal of TC 4.11 is to conduct research on topics that will lead to the development and application of "smart" building systems. "Smart" buildings of the future will take advantage of automation, communications, and data analysis technologies in order to operate in the most cost-effective manner. A smart building would most likely have fully integrated control of building services such as HVAC, fire, security, and transportation. Integrated systems would reduce initial costs and could be "supervised" so as to meet the primary objectives of comfort, safety, and performance at minimum operating cost. In addition, the integration of the hardware and software for operation and monitoring of equipment would lead to reductions in support staff needs and improved equipment reliability. Further cost reductions and reliability improvements would be possible through the integration of automated techniques for detection and diagnosis of equipment faults. Ultimately, "smart" building systems could facilitate the use of "remote" support staff that operates, monitors, and maintains a number of different buildings from a centralized location. At this higher level, a smart building might communicate and inter-operate with other smart buildings for the purpose of load aggregation and centralized control and with outside service providers, such as utilities, energy providers, aggregators, and newly developing companies providing fault detection, automated commissioning, optimization, and other innovative services. In addition to the savings in operating costs associated with "smart" buildings, other benefits include energy conservation and enhanced occupant safety and comfort.

Three subcommittees form the backbone of the TC's activities: Technology Development, Communications and Integration, and Testing and Evaluation. The Technology Development Subcommittee is concerned with research issues associated with the development of emerging smart building technologies such as automated commissioning, performance monitoring, fault detection and diagnosis, optimal maintenance scheduling, and optimal control. The primary outcome of research endorsed by this subcommittee is expected to be data and models that enable development of the technologies and comprehensive methods that are the basis of the technologies. The Communications and Integration Subcommittee is concerned with research issues associated with enabling the seamless interaction of smart building components and services. An important aspect of this work is to identify the information that is necessary to support smart building technologies, and to identify the requirements of communication protocols to

support the exchange of this information between different building services, between buildings and utilities, between multiple buildings, with outside service providers, etc. The Testing and Evaluation Subcommittee is concerned with research issues associated with assessing the benefits (market potential) and performance of smart building technologies. Research endorsed by this subcommittee is expected to result in data, metrics, methods, and tools/standards/guidelines for quantifying smart building system benefits and performance in a standardized manner, as well as findings from the actual application of these metrics, methods and tools.

Current TC 4.11 research includes projects in many of these areas. The evaluation of communication protocol requirements between utilities and energy management systems was addressed in the recently completed research project 1011-RP. Fault detection and diagnostics (FDD) is being considered for a number of different HVAC applications. Demonstration of the performance and benefits of current FDD approaches for air handling systems was performed as part of the recently completed research project 1020-RP. Tools for enabling the assessment of FDD methods for chillers are being developed in 1043-RP, while the development of on-line training techniques for model-based FDD methods is being carried out in 1139-RP for vapor compression equipment.

TC 4.11, Smart Building Systems

Research Plan and Activities
June 2000

Current Research Projects

1043-RP - Fault Detection & Diagnostic Requirements & Evaluation Tools for Chillers

1139-RP - Development and Comparison of On-line Model Training Techniques for Model-Based FDD Methods Applied to Vapor Compression Equipment

2000-2001 Research Plan

Priority	Project	Contributors	Status
1.	Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers – Phase II	John House Srinivas Katipamula	Approved in Minneapolis 10-0-0 (CNV). Submit to RAC AFTER Phase I is completed.
2.	Integrated Control for Building Services	Mike Brambley John House Ron Kammerud John Mitchell	Original TRP Rejected by Tech. Council. Decided in Minneapolis to rework and reconsider in Atlanta. Explore possible ARTI funding. (Needs cover letter to RAC saying this is “second attempt”.)
3.	Field Performance Assessment of Package Equipment to Quantify the Need for Monitoring, FDD, and Continuous Commissioning	Todd Rossi Mark Breuker Jim Braun	Draft WS exists. Todd Rossi will revise and complete BEFORE Atlanta meeting. Possible TC vote in Atlanta.

4.	Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection and Diagnostic Systems	Mike Brambley Todd Rossi	Mike Brambley will scale back scope and have revised WS by Atlanta.
5.	Prototyping and Field Testing of Utility – Consumer Information Services	Michael Kintner-Meyer Marty Burns Chuck McParland	In the hands of an "Action Committee" set up by SSPC 135. Reconsider in Atlanta.
6.	Benchmarking of FDD Tools for AHU's	John House Les Norford	An RTAR exists.
7.	Development of Fault Detection and Diagnostics for Sensor Failures	Phil Haves Arthur Dexter	One page description exists. Two page Issues Paper handed out by Phil Haves in Minneapolis.

RESEARCH TOPIC ACCEPTANCE REQUEST

Title: Evaluation and Assessment of Fault Detection and Diagnostic Methods for Centrifugal Chillers – Phase II

TC/TG: TC 4.11 Smart Building Systems

Research Category: Operation and Maintenance Tools

Research Classification: Basic and Applied Research

TC/TG Priority: 1

Other Interested TC/TGs:

Possible Co-funding Organizations:

State-of-the Art (Background):

Recent research and development efforts have made significant progress toward enabling FDD for vapor-compression equipment; however, given their impact on comfort and energy use, there have been relatively few studies aimed at chillers. To address the need for a comprehensive study of automated diagnostics for chillers, a three-phase research project was initiated in 1998. Phase I was aimed at identifying the important faults for chillers and the sensors needed to detect and diagnose the faults, and developing some of the tools (laboratory chiller data and a simulation model capable of producing

representative chiller data) for testing various chiller FDD methods. A more detailed description of the scope and findings of Phase I is provided in the ensuing paragraph. Phase II will focus on adapting and implementing existing FDD methods for application to a chiller, developing additional tools for assessing the performance of FDD methods, and using the Phase I and II tools to identify the most appropriate FDD method(s) for laboratory and field testing. The third phase of the study will be aimed at performing real-time laboratory and field testing of the FDD method(s) recommended in Phase II in order to ascertain the performance of the tools under non-ideal conditions. It is envisioned that the outcome of Phase III will be a chiller FDD algorithm for incorporation within commercial products.

Phase I (1043-RP) identified important chiller faults and the sensors necessary for detecting and diagnosing these faults. Literature reviews performed as part of Phase I summarized studies of FDD methods applied to HVAC equipment and systems, and chiller modeling. The chiller modeling literature review established that dynamic models capable of capturing the main dynamic characteristics of chillers do not exist. A dynamic model is needed for simulating fault-free and faulty chiller performance under real (steady-state and dynamic) operating conditions so that in Phase II, the output of the model can be used to evaluate thoroughly the effectiveness and robustness of various methods that might be utilized for chiller FDD. The dynamic chiller model is another deliverable of the Phase I project. In addition, laboratory data for normal operation and a number of fault conditions (at various levels of severity) were collected at various load conditions (27 different operating states were considered) for a 90-ton centrifugal chiller. The data collected included both transient and steady state conditions for the following faults: reduced water flow in the condenser, reduced water flow in evaporator, refrigerant leakage, refrigerant overcharge, presence of excess oil, condenser fouling, presence of non-condensables in the refrigerant, and faulty expansion valve.

Advancement to the State-of-the-Art (Justification):

A significant portion of the energy and maintenance costs for operating commercial HVAC systems is associated with chillers. Although current control systems typically monitor many variables, this information is not used for diagnosing faults. At best, these systems incorporate automatic shutdown procedures that guard against catastrophic failures. Although there is a large body of literature on FDD techniques for applications in critical processes and the body of literature for HVAC systems is growing, very little has been published for chillers. Due to the large scope of the problem, studies related to FDD of chillers have typically focused on the development and evaluation of a particular FDD method and have not attempted to perform a rigorous comparison of a variety of FDD techniques. Research is needed to evaluate existing on-line methods for detecting and diagnosing common faults in centrifugal chillers. Furthermore, a side-by-side comparison of FDD methods by a single researcher using a common set of tools will help establish the most promising on-line FDD method(s) for chillers. Identification of reliable FDD methods for chillers will not only improve the operational performance but also reduce both energy and maintenance costs of chillers. This study will provide a major contribution to the field of FDD for chillers by:

- developing methods for evaluating FDD methods for chillers,
- identifying, adapting and implementing in software FDD methods appropriate for chillers, and
- evaluating the FDD methods using tools from Phase I (data and simulation model) and Phase II (FDD assessment tool).

The result of this study (Phase II) will be the identification of an FDD method (or methods) that is recommended for laboratory and field testing in Phase III. The overall impact of the three-phase study will be to advance the FDD technology closer to widespread commercialization. The main benefit to the ASHRAE membership will be a major step in the development of methods that, when implemented in new and existing chillers, will detect and diagnose operating faults before they become problems, thereby reducing maintenance costs, energy costs and occupant discomfort associated with the operation of cooling systems.

Objective:

The objectives of this study are:

1. To develop procedures for evaluating and comparing FDD methods for centrifugal chillers;
2. To assess the performance of FDD methods for chillers using data generated from a dynamic chiller model and data collected from laboratory tests;
3. To recommend cost effective chiller FDD method(s) for real-time laboratory and field testing in Phase III.

RESEARCH TOPIC ACCEPTANCE REQUEST

Title: Integrated Control for Building Services

TC/TG: TC 4.11 Smart Building Systems

Research Category: Operation and Maintenance Tools

Research Classification: Basic and Applied Research

TC/TG Priority: 2

Other Interested TC/TGs:

Possible Co-funding Organizations: ARTI

Background / State-of-the Art:

Integration of the control of multiple building services such as HVAC, fire, security, and transportation may offer many benefits to building owners and operators. First-cost benefits can accrue if individual systems can serve multiple functions: for example, an EMCS can control both the HVAC and lighting systems. Operating cost benefits can also be achieved: for example, operating schedules for HVAC and vertical transport can be better coordinated if there is a single supervisory control node. Finally, operational efficiencies can be achieved through integration of systems by reducing the number of different systems in a facility, thereby reducing demands on the building operators. Integrating the control of multiple building services is not an innovative concept. The benefits cited above have motivated efforts to integrate the control of building services for many years, with many

different approaches having been taken and different levels of success having been achieved. An objective study documenting what systems have been integrated in the past and why, what has been successful and what has failed, and what are possibilities for the future is needed to help decision makers understand the potential and limitations of various integration approaches they might consider.

In the context of this project, integration is the product of a design that is proactive in exploiting opportunities to reduce redundancies in the operations and control capabilities for the different building systems. The result of integration is a building where the systems work effectively together to maximize cost effectiveness, energy efficiency, reliability, and occupant satisfaction. Hardware and communications technologies are major ingredients in achieving this end, but they do not ensure success. The fundamental issue is not how communication between systems is achieved, but rather, what information is communicated, and what is done with that information. In this project, levels of integration associated with building services will be examined in order to (1) improve understanding of what is being integrated and why, (2) understand the benefits and costs of different approaches to integration, and (3) identify meaningful indicators of success.

Advancement to the State-of-the-Art (Justification):

Building owners and operators are responsible for operation and maintenance of many of the services provided in their building, including, but not limited to, HVAC, illumination, fire, security, and transportation. These building services are increasingly coming under the control of both distributed and centralized control systems. Vendors also offer a number of different approaches for collecting and displaying information on the operation and performance of these systems. BACnet and other communications protocols are now available to facilitate integration of control and/or information content services. However, several obstacles to achieving successful integration of building services remain:

- General guidelines are not available to help an owner or operator decide on those services that should be included in an integrated approach and those that should not.
- Advantages and disadvantages of including individual services in an integrated system have not been established.
- Indicators of effective (or ineffective) integration have not been identified.
- Objective information and tools produced by an impartial source that provide a basis for integrating services are not available to the design community.

Although integrated control of multiple building services has been performed at different levels for years, there is a general lack of understanding of what should be integrated, why it should be integrated and how it should be integrated. This research project will provide valuable information on the benefits associated with the effective integration of building services. The results should significantly improve the design decision-making process for engineers, owners, and operators, and is expected to identify tools and information needed to support and facilitate integration during design. This research is needed by the sponsoring committee to assess the needs for possible ASHRAE standards and/or guidelines on evaluating and choosing the best approach to integrating building services in different applications. In addition, the project may identify needs for communications protocols or other technology that can make integration a more practical and achievable option.

Objective:

The objectives of this project are:

1. To provide a succinct description and assessment of the state of the art of integrated control through survey of stakeholders and field analysis of buildings representing examples of effective integration of systems;

2. To define the benefits of integration by identifying the interactions (type of interaction, information exchanged, command and control decisions, assumptions made by one system about another system, etc.) between different building services necessary for normal operational situations and those necessary for other situations such as in response to a fire alarm;

3. To quantify the economic impact of effective integration;

4. To identify the technical and economic characteristics indicative of effective integration;

5. To identify opportunities for research directed at advancing the capabilities of the design community to specify and achieve integrated control designs.

RESEARCH TOPIC ACCEPTANCE REQUEST

Title: Field Performance Assessment of Package Equipment to Quantify the Need for Monitoring, FDD, and Continuous Commissioning

TC/TG: TC 4.11 Smart Building Systems

Research Category: Operation and Maintenance Tools

Research Classification: Basic and Applied

TC/TG Priority: 3

Other Interested TC/TGs: TC 9.9

Possible Co-funding Organizations: BOMA

State-of-the-Art (Background):

Packaged HVAC equipment is the most common source of heating, air conditioning, and ventilation in small and medium size commercial buildings, including popular suburban retail shopping malls, supermarkets, and restaurants. A recent DOE report indicates that rooftop and unitary A/C equipment consumes 1.03 out of a total of 1.66 quads (62%) of total energy consumed for cooling the current building stock of commercial buildings in the US. Compared to large built up systems, packaged equipment are generally smaller and more numerous. Therefore, service technicians do not spend nearly as much time on each unit. As a result, their actual field performance may be much worst than their counterpart in built up systems. It is not known how this equipment is actually performing in the field. If there is great potential, new measurement and information technology tools as well as new service procedures need to be developed and applied to package HVAC equipment in order to improve long term performance.

Advancement to the State-of-the-Art (Justification):

The motivation for this research arises from recent ASHRAE-sponsored research projects in TC 4.11 and TC 9.9 to study commissioning and fault detection and diagnostic technology for HVAC equipment, including 1020-RP, 1043-RP, and 1139-RP. These research projects primarily focus on air handling units and large chiller plants used in larger facilities. This research project will assess the need for similar technology for packaged HVAC equipment. If the need is there, the results or this work should help guide future efforts in ASHRAE, government, and industry to develop diagnostic and service procedures and to document their costs and benefit. The focus of the work will be on roof top unit performance, since these systems have a direct impact on occupant comfort, indoor air quality, and facility energy use in a large fraction of commercial buildings in the US.

Objective:

The objectives of this research project are to:

1. Study and document the actual field performance of a large number of packaged roof top units and compare the results to industry norms or manufacturer's specifications,

1. iImplement diagnostic and service procedures on a subset of these units and measure and document the resulting performance improvement, and

1. Recommend additional research on the development of appropriate measurement and information technology tools and new service procedures that will significantly improve the long-term performance of package roof top HVAC systems.

RESEARCH TOPIC ACCEPTANCE REQUEST

Title: Resolving Discrepancies Between Multiple, Hierarchically-Related, Fault Detection, and Diagnostic (FDD) Systems

TC/TG: TC 4.11 Smart Building Systems

Research Category: Operation and Maintenance Tools

Research Classification: Basic and Applied

TC/TG Priority: 4

Other Interested TC/TGs: TC 4.6

Possible Co-funding Organizations:

State-of-the-Art (Background):

Large systems, including buildings, can be represented in a hierarchical structure where the entire system is divided into sub-systems, which are in turn divided into sub-sub-systems. Fault detection and diagnostic (FDD) methods or software modules can operate on one or more levels or at different levels throughout this hierarchical structure. Such systems promise to provide the greatest benefits for large systems (e.g., all the HVAC equipment in a 40 story building) that need the hierarchical structure to divide the system into manageable components, but the hierarchical structure could be applied to smaller buildings and may be of value in implementing the diagnostic processes themselves.

When FDD methods operate on hierarchically-related entities, they may produce results that contradict one another. Subsystems have interactions (consider, for example, the chilled water temperature that is produced by the chiller and used by cooling coils). This, along with uncertainty in measured conditions, creates the potential for overlapping and conflicting results when FDD methods are applied to different individual entities at different levels or subsystems in the hierarchy. For example, the chiller FDD might call for a warmer chilled water temperature while some of the cooling coils it serves call for a lower chilled water temperature. For a building operator to use advice from these distributed, independent FDD systems, some coordination of their results or resolution of conflicts is needed. Conflict resolution might be done manually by the FDD user (e.g., building operator), automatically at a supervisory level (e.g., on the operator workstation), or automatically at distributed points in the FDD system.

This work statement focuses on resolving conflicts between FDD solutions that are likely

to utilize distributed computing (i.e.. processing takes place at multiple locations distributed through out the building and/or control system), but it also applies to FDD methods implemented as separate processes or software modules run on the same computer.

Advancement to the State-of-the-Art (Justification):

Fault detection and diagnostic (FDD) techniques are emerging from research and are beginning to be tested in real buildings. Many of these techniques focus on specific HVAC subsystems or components of them; others operate at the whole-building level to identify performance anomalies and identify subsystems causing the anomalies. At the same time, control functions are becoming more distributed with much control processing (computing) taking place at the device or subsystem level, rather than at a central (building-level) location. This provides opportunities for the use of distributed FDD in conjunction with distributed control, yet creates the need to coordinate and resolve conflicts between diagnostic results produced by different FDD systems. This research project responds to that need by providing information that will be needed by the HVAC professions to

successfully apply distributed FDD in buildings by developing and evaluating methods for resolving conflicts between FDD systems.

Objective:

The objective of this research is to investigate how results from FDD methods applied separately to distributed and hierarchically-related HVAC subsystems and equipment can overlap and potentially conflict with one another. Then, based on this investigation, identify or develop, test and evaluation methods for resolving these conflicts. The final results of this research will be a well-documented evaluation of methods for overcoming conflicts generated by FDD methods or software along with guidance regarding circumstances under which to use each adequately-performing method. The final document shall include detailed examples of method applications.

RESEARCH TOPIC ACCEPTANCE REQUEST

Title: Prototyping and Testing of Utility/Customer Information Services

TC/TG: TC 4.11 Smart Building Systems

Research Category: Operation and Maintenance Tools

Research Classification: Advanced Concepts

TC/TG Priority: 5

Other Interested TC/TGs: TC 1.4, TC 1.5

Possible Co-funding Organizations:

State-of-the-Art (Background):

Utilities and telecom companies have been experimenting with energy and non-energy information services for several years. Most of the experimentation has been performed in small-scale pilot programs with a relatively small number of participants. The majority of the technology

implementations are centered around providing services such as automatic meter reading, outage detection, and real-time-pricing (RTP) transmission. Only recently, spurred by the restructuring efforts in the electric power industry and the Telecommunication Act of 1996, has the industry has made bolder steps in marketing and implementation of information services.

On-site power generation from emergency generators has only recently been offered by technology companies and generator manufacturers. Web-based applications have emerged that provide gateway capabilities to interface commonly used EMCS. These systems can be bundled with other asset management services to provide full solutions to property management companies and ESCOs for load management, energy efficiency monitoring, alarm response, and diagnostics, as well as providing facility management functions such as asset inventory, facility maintenance scheduling and automated processing of work orders and procurement.

Direct load management applications are predominant in residential homes, where appliances such as air conditioners, pool pumps, and water heaters were cycled during peak times to reduce load. Most of the residential information services offered are Internet and cable TV services. However, given that a communication infrastructure is being developed by means of these applications, the same communication device transmitting entertainment information can be used to transmit energy information service in future applications.

By and large, utility trials have focussed on implementing some targeted applications. Most of these were not concerned with the development of underlying communication infrastructures that would provide interoperability across network and communication technologies. Now the industry needs to complete the development of standards necessary to enable these services to a broad customer base including commercial, industrial and residential customers. Significant steps toward that end have already been done. The Electric Power Institute (EPRI) with its Utility Communication Architecture standardization efforts and, recently, ASHRAE with its support of research project 1011-RP are providing a systematic approach toward defining communication standards targeted at utility-customer communications.

Advancement to the State-of-the-Art (Justification):

As a natural extension of ASHRAE research project 1011-RP, "Utility/Energy Management and Control System (EMCS) Communication Protocol Requirements", a two phase project for prototyping and field testing a set of selected information services defined in research project I011-RP is proposed. Phase I will focus on the prototyping and testing of information services under lab conditions in which the communicating parties are

simulated. In Phase II, field trials will be proposed to implement and test the prototyped information services at 3-5 customer sites under real-world conditions. This ATAR describes Phase I only. Phase II will be defined in a later, separate ATAR.

The primary objectives of research project 1011-RP were: 1) to identify potential new information services that utilities or electricity suppliers are likely to offer to their customers, 2) to determine the communication and data requirements to establish these services, and 3) to develop data object models that support interoperability for the implementation of the services. This project will build on this previous work. It will implement and test selected information services for commercial/industrial and residential applications in BACnet and CEBus environments. To expedite the prototyping and testing phase, the development is proposed to be performed in a simulated environment in which the communication between a utility/service provider and its customers is simulated in several networked computers under laboratory conditions. This work is specifically designed to verify the completeness, usability, of the set of data object models developed in 1011 - RP through a real implementation. By using the BACnet protocol for in-building communication it will build on and support the ASHRAE's standards work.

Objective:

The implementation of a prototype of selected energy/information services will target the

following objectives:

1. To verify the completeness of the data object and device models for selected energy and information services proposed under ASHRAE 1011-RP. The implementation will check the completeness and provide a basis for proposing enhancements/ modification to the object models.

2) To test the mapping of the data object models to BACnet and CEBus protocols, since the seamless bidirectional transport of information is imperative for robust communication.

3. To provide experience with real implementation and provide the credibility and the refinement necessary to establish communication standards for energy/information services.

3. To assist the development of communication software necessary for the preparation of energy/information services to be studied in field trials during Phase II.

RESEARCH TOPIC ACCEPTANCE REQUEST

Title: Benchmarking of FDD Tools for AHUs

TC/TG: TC 4.11 Smart Building Systems

Research Category: Operation and Maintenance Tools

Research Classification: Basic and Applied Research

TC/TG Priority: 6

Other Interested TC/TGs:

Possible Co-funding Organizations:

State-of-the Art (Background):

This RTAR proposes a follow-on study to ASHRAE 1020-RP, "Demonstration of Fault Detection and Diagnostic Methods in a Real Building". The objective of 1020-RP was to demonstrate FDD methods in a real building, to assess the strengths and weaknesses of the methods investigated, and to provide guidance for future research in this area that will accelerate the development of FDD technology. The comparison included data for seven different faults collected during multiple seasons of the year. Both abrupt and degradation faults were considered. The data was collected at the Iowa

Energy Center Energy Resource Station, a real building that serves as a test facility for energy-efficient technologies. The test procedure consisted of the following three steps:

1. preliminary commissioning tests,
2. one-week of control tests in which faults were implemented and the researchers were told what faults were implemented (including severity), at what time they were implemented, and for how long they were implemented, and
3. one-week blind tests in which the researchers knew only that the faults considered during the control tests would be implemented at some time during that week.

Step 1 was performed once, while steps 2 and 3 were performed once during summer conditions, again during winter conditions, and a final time during spring conditions. Both FDD methods proved capable of consistently detecting the faults, with a small number of exceptions. Fault diagnosis procedures were improved over the course of the tests and at the conclusion were also generally effective. However, diagnosis was made considerably easier than in what are likely to be typical conditions, due to the limited number of known faults, the known magnitude of the faults, and the excellent maintenance of building equipment and sensors.

The test procedure was then altered in order to evaluate the performance of the methods without the benefit of the control test data. The new test procedure was carried out on a different AHU and the researchers were not told what faults were implemented. The performance of the methods suffered with the removal of step 2. In particular, the ability to diagnose the implemented faults was poor.

Advancement to the State-of-the-Art (Justification):

Prototype FDD tools for AHUs have been in existence for approximately two years. It is estimated that there are at least eight to 10 AHU FDD tools at various stages of development. At least one of these tools is being sold to building owners and operators, although none are currently implemented directly in energy management and control systems. Controls manufacturers are moving toward implementing FDD capabilities in their controllers, but they are moving cautiously because the technology is still in its infancy. Further assessment of prototype FDD tools for AHUs would assist controls

manufacturers in their efforts to identify the most promising tools for evaluating the operation of AHUs. This will speed the commercialization of this technology, thereby benefiting building owners, operators, and occupants by helping ensure the buildings are comfortable and utilize energy efficiently.

ASHRAE 1020-RP pointed out how difficult it is to detect and diagnose faults in real buildings. Furthermore it pointed out how difficult it is to evaluate the tools. The proposed study would entail blind testing of FDD tools by an independent party using data produced in a real building. This would eliminate the expert knowledge of tool developers from the evaluation and would help establish how well the tools can be used by someone other than their developers. The data produced will include a number of common faults introduced in a controlled and repeatable manner. The data will be one of the deliverables of the project and will be useful for further developmental work related to FDD tools.

Objective:

The primary objective of this study is to perform an independent assessment of FDD tools for AHUs to establish their capabilities to detect and diagnose faults in a real building. A secondary objective of the study is to produce AHU data sets with embedded faults that can be used by developers to test their FDD tools.

TC 4.11, Smart Building Systems

Research Project Description

Priority 7

Project Title: Development of Fault Detection and Diagnostics for Sensor Failures

Summary: The purpose of this research is to develop Fault Detection Diagnostics (FDD) methods for detecting failed sensors of the type that are typically used in HVAC systems, including: temperature sensors, electricity sensors and flow sensors. Examples of known FDD sensors techniques include: high-low limit comparisons, model comparisons, sensor redundancy, and analytical redundancy. This work would be beneficial to implementing Fault Detection Diagnostics that are dependent on the accurate data from a suite of sensors.

Objectives: This objectives of this research include: (1) a thorough literature search into the current methods that are used to detect sensor failures of the type that typically used in HVAC systems, (2) the development of a suite of FDD procedures for HVAC sensors, and (3) the testing and verification of the developed FDD procedures on specially prepared data from sensors that contain known faults.

Benefits: The project will benefit ASHRAE membership as well as the general public as follows:

1. Assist ASHRAE to develop methods to detect fault diagnostics in sensors.
2. Help equipment suppliers as an aid for incorporating FDD techniques into equipment.
3. Encourage the documentation of such methods.
4. Allow ASHRAE to develop more effective training programs for teaching engineers and architects how to apply FDD methods to sensors.

5. Improving energy efficiency by providing ASHRAE members with improved methods for sensor FDD.

Estimated Cost: $75,000

Estimated Duration: 18 months

Methods of Publishing Research Results:

Detailed Reports

Technical Paper(s)

Appendix H.

TC 4.11 Smart Building Systems

Program

Chairman: Carol Lomonaco

I. TC 4.11 SPONSORED PROGRAM FOR THE MEETING IN ATLANTA, JANUARY 30, 2001

Symposium AT-01-14: Recent Results from Fault Detection and Diagnostic Research, Tuesday, 1/30/2001 - 10:15 AM - 12:15 PM, Room: 365/366W, Chair: Les Norford

Seminar 29: Adding New Life to Old Systems: Control Retrofit Case Studies, Tuesday, 1/30/2001, 10:15 AM - 12:15 PM, Room: 364W, Chair: Gaylen V. Atkinson

Seminar 46: Diagnostics from an Operations Perspective: Needs and Experiences, Wednesday, 1/31/2001, 10:15 AM - 12:15 PM, Room: 363W, Chair: Todd M. Rossi

II. TC 4.11 voted on sponsoring the following programs for Cincinnati (June 23-27, 2001). The deadline for submitting to ASHRAE by Friday, February 9, 2001:

Priority 1, TC 4.11 Sponsor and TC 1.4, 1.5, 4.6, SSPC 135 Co-Sponsors, Seminar

"BACnet Manufacturer's Association (BMA) New Role in Testing the Interoperability of BACnet Systems"

Chaired by H. Michael Newman

Priority 2, TC 4.11 Sponsor and TC 1.5 & TC 4.6 Co-Sponsors, Seminar

"Data-Modeling for Buildings Operation"

Chaired by Michael Kintner-Meyer

III. TC4.11 voted on and an agreed to co-sponsor the following programs for Cincinnati:

Priority N/A, TC 1.4 Sponsor and TC 4.11 Co-Sponsor, Seminar

"Wireless DDC Control: Working a Net Without a Wire"

Chaired by Barry Bridges

Priority N/A, TC 1.7 Sponsor and TC 1.4, 1.5, 4.6, & 4.11 Co-Sponsors, Seminar

"Maximizing Facilities Performance with Computerization."

Chaired by James Gartner

Priority N/A, TC 1.5 Sponsor and TC 1.4, 1.5, 1.7, 4.6, & 4.11 Co-Sponsors, Seminar

"Pattern-Recognition-Based Fault Detection and Diagnostics for Building

Operation"

Chaired by Michael R. Brambley

Priority N/A, TC 1.9 Sponsor and TC 4.11 and TC4.6 Co-Sponsors, Forum

"What is ASHRAE's Role in Designing and Operating Buildings for More Frequent Power Interruptions?"
Chaired by Mike Kuk (pronounced "Cook")

IV. The following programs will be evaluated in Cincinnati by TC 4.11 possibly for the Atlantic City, January 12-16, 2002 or Honolulu, June 22-26, 2002. [Chairs must confirm that their speakers will be available for Atlantic City.] The deadline for submitting program to ASHRAE is Friday, August 3, 2001:

FUTURE, TC 4.11 Sponsor and TC 1.4 & 1.7 Co-Sponsors, Symposium

"Recent Results from Fault Detection and Diagnostic Research Part II"

Chaired by John House

FUTURE, TC 4.11 Sponsor and TC xx & TC xx Co-Sponsors, Seminar

"Experience with California's Price Responsiveness Program

Chaired by Michael Kintner-Meyer

FUTURE, TC 4.11 Sponsor and TC 4.6 Co-Sponsor, Seminar

"Intelligent Agents - What They Can Do For Your Building?"

Chaired by Osman Ahmed

FUTURE, TC 4.11 Sponsor and TC 1.4 & TC 1.5 Co-Sponsors, Forum

"Addressing the Need for Data Modeling Beyond Building Design – What Role Should ASHRAE Play?"

Chaired by Godfried Augenbroe and Osman Ahmed

FUTURE, TC 1.4 Sponsor and TC 4.11 Co-Sponsor, Forum

"Specifying Open LonMark DDC Systems"

Chaired by Ofer Pittal or Mike Pouchak

FUTURE, TC 1.4 Sponsor and TC 4.11 & TC 1.5 Co-Sponsors, Forum

"How Should the Handbook Cover Network Technology"

Chaired by Monica Malfitano or Mike Pouchak

Submitted by

Carol Lomonaco

Appendix I.

List of Subcommittee Attendees

Minneapolis: January 1, 2001

		Tech Dev	Comm Integration	Test Eval
Voting Members				
Jim Braun	99-01	x	x	x
Les Norford	99-03	x	x	x
John House	99-03	x	x	x
Todd Rossi	99-03	x	x	x
Rich Hackner	98-02	x	x	
Mark Breuker	99-03	x	x	x
Michael Kintner-Meyer	99-03	x	x	x
Steve Blanc	99-03			
Barry Bridges	98-02			
Natascha Castro	00-04	x	x	x
James Gartner	98-02			
J. Carlos Haiad	00-04			
John Seem	99-03			
Non-Voting Members				
George Kelly (CM)	99-	x		x

Mark Bailey (CM)	98-			
Carol Lomonaco (CM)	00-	x	x	x
Michael Brandemuehl(CM)	99-			
Charles Culp (CM)	00-			
Arthur Dexter (Intl)	96-00	x	x	x
Tom Engbring (CM)	99-			
Phil Haves	00-			x
David Kahn (CM)	96-			
Brian Kammers (CM)	96-			
Curt Klaassen	99-			
John Mitchell	96-00	x	x	x
Ron Nelson (CM)	98-			
Robert Old (CM)	00-	x	x	x
Barry Reardon (CM)	99-			
Meli Sylianou (CM)	99-			
Jim Winston (CM)	96-			
Agami Reddy		x	x	x
Andrew Price		x	x	x
David Craven		x	x	
Edward Morofsky		x		
Gene Strehlow			x	x
Jean Christophe Visier				x
Jeff Haberl		x	x	
Jonathan Wright		x	x	x
Kristin Heinemeier				x
Marty Burns		x	x	x
Mike Brambley		x	x	x
Peter Armstrong		x	x	

Pornsak Songkakul	x		x
Richard Kelso			x
Robert Veelenturf	x	x	
Srinivas Katipamula	x	x	
Stuart Waterbury	x	x	x
Vojislov Novakovic	x	x	